OCEANS OF TROUBLE

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MANAGING TO FAIL

> In theory, saving the fish is simple: Count them, decide how many you can spare, and limit the catch accordingly. In practice, fishing has proven extraordinarily difficult to manage. The science of 'counting' fish is really closer to educated guessing. And when the numbers point to trouble, as they did in the case of the red snapper, the industry and the politicians too often shout down the warnings and guarantee collapse.

Managers maneuver at cliff's edge

By JOHN McQUAID, *Staff writer*

In late October — a time of blustery, changeable weather in the Gulf of Mexico — the government decided it was time for a little red snapper fishing. The shimmering snapper, sought after by haute chefs and family cooks alike, is off-limits to commercial fishing in the Gulf most of the year. It was overfished through much of the 1980s, scientists say, and its population still hovers dangerously close to collapse. But officials had miscalculated the closing date for the season the previous March, and the commercial catch had come in 210,000 pounds under quota. The solution, requested by the fishing industry, was a 36-hour makeup season.

From Texas to Florida, hundreds of boats set out in a mad midnight scramble. But the weather didn't cooperate. Two miles south of Grand Isle, a whistling east wind and 5-foot seas forced Capt. Ron Anderson to turn his boat around and head home. Three hours before the starting time, officials postponed the derby for two days. By the time Anderson made it out, the time limit left him stuck in an area already picked over by boats that had ignored the postponement or gotten an earlier start. He came back with a disappointing 600 pounds of snapper, well under his 2,000-pound limit.

It shouldn't be such a hassle to go fishing. But despite the best intentions of the snapper's caretakers, efforts to preserve it have gone spectacularly awry, endangering both the fish and the livelihoods of the people catching it. The struggle to manage the snapper mirrors hundreds of other battles to protect valuable fish populations, situations where the best science has often failed, and a maze of regulations can do more to alienate fishers than save fish.

In the Gulf, no other fish has gotten more care and attention than the red snapper. Dockside monitors, number crunchers, biologists, economists, anthropologists and regulators have collected reams of data, run complex computer models and written sheaves of rules in their struggle to

bring the fish population back from depletion. It hasn't worked. The snapper population is bigger than it was at its lowest point, but scientists say it is decades away from complete recovery.

The snapper's problems are not unusual. For the most part, marine fisheries are ruled by crisis management that kicks in only after a fish population has dropped dramatically and jobs are being lost. The result is an approach one wry observer termed MAD: Management After Depletion. ''One of the founders of our field once said that fishery science is based on elegant post-mortems,'' said Bradford Brown, director of the National Marine Fisheries Service's Southeast Fisheries Science Center in Miami.

Science is at the base of the system. But it was a rickety foundation from the start. Scientific data about fish populations is always sketchy, and that makes it vulnerable to political pressures. As fish populations plunge, the politics becomes more desperate and the science more irrelevant. ''The management process has helped destroy this fish and it's doing a pretty good job on us too,'' said Anderson, who has been on several fishery management committees.

Twenty years ago, the government barely paid attention to fishing. But when the United States expanded its jurisdiction to 200 miles offshore in 1976, it set up regional fishery management councils — advised by the Fisheries Service — to oversee fishing in its new domain and work with state agencies. Overfishing began almost immediately, causing widespread damage before anyone could get a handle on the problem. Agencies have been behind the curve ever since.

The arrangement wasn't designed to control the size of fleets, the biggest pressure on fish, or do much about protecting coastal habitat, the other major source of trouble. Its decentralized structure is supposed to help build consensus, but just as often it has caused political paralysis.

Rules aren't cutting it -- ''Fisheries have been managed with the same principles for the last 100 years, and look at the fish stocks — they're a disaster,'' said international fishery consultant Francis Christy. There are now more fishery regulations — international, federal and state — than ever before. Yet fish populations are in worse shape than ever before.

One good indicator of the trend can be found in the Federal Register, which publishes all regulatory changes, seasonal openings and other parts of the Fisheries Service's management plans, just a fraction of all the rules and regulations affecting fisheries. In 1980, there were 14 regulations listed in the register. In 1984, when the councils first started implementing comprehensive management plans, there were 226. In the first three quarters of 1994, there were 417. U.S. fisheries are vast and diverse, and management has worked in some cases, such as many of the bountiful Alaskan fisheries. Gulf redfish, which are not related to red snapper, were decimated a decade ago but are making a strong comeback under a strict management system. But on the whole, the regulatory buildup has slowed but not stopped the depletion of fish populations across the country.

The Fisheries Service says 80 percent of the species groups it has enough data on to characterize are overfished or fished at their limit, up from 68 percent in 1977.

During the same period, the country as a whole was catching fewer fish, and the value of those fish fell — except in the West, which experienced a vast expansion in landings of inexpensive Alaskan pollock in recent years. That contraction, along with a quantum shift to larger boats and more mechanization, has put tens of thousands of people out of work, and the trend continues

today. This is a recipe for upheaval, and it has spawned political fights in fisheries everywhere, including the red snapper fishery.

Gambling the future -- When some fish populations fall very low, any additional pressure can send them spiralling into a collapse from which they might never recover. Fisheries Service biologist Phil Goodyear's most recent assessment says the snapper population may be on the edge of that cliff. If it's true, he wrote, ''any decline in the spawning stock below current levels should be strongly avoided, as it could lead to precipitous population declines.''

Goodyear estimates it will take until 2019 to rebuild the snapper population to a healthy, sustainable stock — and that's only if a solid plan is put in place immediately. Instead, under pressure from the commercial fishing industry, the Gulf of Mexico Fishery Management Council recently voted to allow more, not less, snapper fishing. It raised the annual limit from 6 million to 9 million pounds, based on the hope that the incidental catch of young snappers by shrimp trawls will be cut in half starting next year. Forty million young snapper were caught by trawls in 1994, and Goodyear says slashing that number is crucial to the species' survival.

The problem is that by-catch reduction has been politically gridlocked for years because shrimping, the biggest Gulf fishery, has a lot of political clout, and managers are swayed as much by political as by scientific arguments. ''They're gambling the future of the fish,'' Goodyear said. ''But I've given up worrying about it.''

Red snapper's demise -- The snapper is a reef fish, which tend to congregate on hard bottoms and underwater structures: rocks, coral reefs, oil rigs and shipwrecks. That makes them easy to find and catch in large numbers. Snapper are also slow-growing and long-lived; the oldest fish recorded was 53. They were thus easy to deplete: Fishing killed so many adults that those remaining couldn't reproduce quickly enough to replace them.

Trawling and overfishing sent the catch plummeting between 1981 and '87, when the estimated combined commercial-recreational catch fell from 16.9 million pounds to 5.1 million pounds, a decline of nearly 70 percent. The council delayed taking serious action until 1990. The chief reason was scientific uncertainty. Because dramatic fluctuations in annual catches can occur even during periods when a fish is not in decline, such drops are often dismissed until it's too late, a mistake that wiped out key fish populations in New England. ''A lot of it was not knowing what was going on,'' Andrew Kemmerer, Southeast regional director of the Fisheries Service, said of the failure to detect the red snapper collapse sooner. ''The science was slowly becoming more reliable, but the managers were not paying attention to it. Had the council been confronted with the same kinds of information with the same level of precision we have now, things might have turned out differently.''

Estimates, guesses -- Fishery biologists are studying something they can neither see nor measure directly. Fish populations are, after all, under water, spread out over wide areas. During spawning, they release millions of eggs, a fraction of which will survive for reasons scientists can only guess at. It takes years or even decades to gather reasonably comprehensive data, which must be painstakingly assembled from historical catch statistics, data on length and age gathered by dockside agents, and sampling by government research boats equipped with trawls.

Agencies don't have the time and resources to identify problems before they turn into full-blown crises. They usually focus on the most economically important or most depleted fish. Or both, in the case of red snapper. When they assemble their data, it is almost always inaccurate.

Commercial fishers often underreport their catch, because they don't want to fill a quota, or exceed a trip limit. Data from sport fishing boats are even sketchier, gathered from projections of data gathered from voluntary surveys.

Once they have data, scientists must try to fit it into a model of how the fish population is structured by age and how it changes year to year. But to fill in the gaps, scientists make assumptions — in some cases, assumptions built upon assumptions. Take the problem with shrimp trawls. According to Goodyear's assessment, they are the main reason the snapper remains in such bad shape. He estimates they kill more than 85 percent of all baby snappers each year. To get that number, Goodyear combined three pieces of information. He took data from sample trawling done by research vessels that break down how many fish of each kind are caught on a given run. He took data on the activity of shrimp boats operating in the same area. He made a guess at the rate fish die of natural causes. He crunched it all in a computer model to estimate how many fish there were to start with and how many were left after the trawls got to them.

Goodyear defends the process, saying data from many sources corroborate each other in his model. But he concedes it is based on assumptions that could be wrong; that's the nature of the scientific method. It's no surprise that snapper fishers dispute his findings.

''There's plenty of fish out there. The Goodyear report is just plain wrong,'' said snapper boat captain Wayne Werner of Golden Meadow. Goodyear says it's a difference in perspective. There are more fish because regulations have had some effect, he says. In addition, an unusually high number of baby snapper were born in 1989. Such short-lived fluctuations are common in fish populations. They do not change the long-term trends, but they do often undercut arguments for restrictions on fishing — another reason action was delayed in New England.

But Goodyear's assessment is based on data stretching back 20 years, collected over the entire Gulf of Mexico. He says fishers aren't wrong, but that they haven't analyzed the big picture. Scientists and managers must look at the long term. They want to maintain the size of the fishing fleet and keep the fish population at sustainable levels, so that revenues remain consistent and there are enough fish year after year. Fishers usually have their eye on the short term. Because many fishing fleets are too big, the pressure is great to fish as much and as quickly as possible, even when populations are low.

Moving a decimal point in a scientific assessment can mean the difference between recovery and virtual extinction. It also can mean millions of dollars. ''It's a two-edged sword," said Environmental Defense Fund scientist Rod Fujita. "If you err on the side of conservation, you're attacked. If you err on the side of too much fishing, the fish disappear.''

Fishing industry groups now routinely attack assessments that don't favor their goals, and they often succeed in delaying and sometimes torpedoing measures to protect fish populations. If an industry is big enough, it can appeal to members of Congress. Members have routinely intervened in New England and in the Gulf to undermine the Fisheries Service and the regional management councils. Elected officials usually share the same short-term goals of keeping constituents working and their businesses operating. In the process, any credibility and authority the science has is undermined.

Rules unfathomable -- While merely analyzing the snapper population has sparked bitter fights, attempts to protect it have confused and angered snapper fishers, the very people who ought to be supporting the effort. The rules have changed year to year and sometimes month to month. For

most workers, this would be like having their office moved and hours changed on a regular basis, with their pay going up and down constantly, all dictated by people rarely if ever seen.

The tough regulations started in 1990. An overall quota was put in place for the first time. Special permits were required to fish for reef fish. To allow the fish to grow and reproduce, regulators established size limits for both commercial and sport fishing — currently, a minimum of 15 inches. Recreational fishers also got bag limits — seven fish at first, now five.

As the regulations took hold, fish became more plentiful, and it took less and less time to catch the limit. The commercial season, 95 days in 1993, shrank to 51 days last year. The short season is a headache for fishers. Competition for fish is intense, and finding them is harder. Because so many fish arrive at the docks at the same time, the price drops, sometimes as much as $1 a pound in a single day. It's also hard to measure the catch accurately as it comes in — hence the 36-hour mini-season last year.

The quotas also are unfairly applied. Though sport fishers technically operate under a quota, officials do not have the resources or a system to count the sport catch. As a result, sport fishers often exceed it by large margins — 40 percent in 1994, according to the Fisheries Service. As managers struggled to limit fishing, the system grew more and more complex.

In 1992, trip limits took effect, starting at 1,000 pounds for all boats. The next year, managers shifted to a two-tiered system in which 131 ''historical'' red snapper fishing boats were authorized, with a 2,000-pound-per-trip limit. All other commercial boats had their catches capped at 200 pounds per trip. The red tape caused mistakes. In 1992, for example, officials were overwhelmed with permit applications. So they waived the permit rule. Suddenly, anybody could fish for snapper. ''I had outboards fishing around me,'' Anderson said.

Some quit, others hope -- Riding this regulatory merry-go-round has proved too much for many snapper fishers. Jim Gerard lives on his boat, the Long Gone, usually docked in Leeville. He had been fishing for five years, often taking huge snapper catches, when he took a job on a supply boat in 1989, was injured, and did not return to fishing until 1992.

Meanwhile, the Gulf Fishery Management Council had declared that the sought-after snapper ''endorsements'' guaranteeing a 2,000-pound limit per trip would go only to fishers who had caught 5,000 pounds of snapper for the past three years.

Gerard was shut out, stuck with a 200-pound limit. For others, all the paperwork proved overwhelming. Golden Meadow fisherman Leon Elliot captained two boats during the same period. But he was unable to produce a key logbook he said he never knew he had to fill out, and he couldn't get an endorsement either. ''A lot of us are not very educated and that kills us right there. This stuff is so complicated,'' Elliot said.

Around the world, agencies are giving up on the management-by-regulation approach, and managers want the snapper to be part of the change. Under a proposal already approved by the Gulf Council, the snapper would be one of the first fisheries in the country to get a new system called an Individual Transferable Quota, a legal right to a fraction of the total catch set each year that the fisher can sell or lease. The change would simplify the regulatory web. A boat could take fish any time of year, as long as it didn't exceed its annual quota.

Snapper fishers are divided on the concept. Anderson avidly supports it. But others fret that it will unfairly shut out some, like Gerard and Elliot. Others fear it will end up costing them money. After creating quota shares that have value, the government may want something in exchange to finance the program. But congressional opposition may torpedo the new snapper program. Managers have been ordered not to implement it while Congress wrestles with the issue. The House has voted to ban a key element of the plan — the transferability of the quotas — and the Senate is leaning toward creating a moratorium on them.

Scientists confounded by nature, politics

By JOHN McQUAID, *Staff writer*

NEW BEDFORD, Mass.

The Narragansett rumbled out of the soft mist before 8 p.m. The captain steered the black-hulled dragger up to the RCC Seafood dock, while crew members and workers from Fish Lumpers Union Local 1749 readied their shovels and buckets to offload the catch.

At the height of New England's fisheries boom 10 or 15 years ago, offloading was more like shoveling cash than fish. Gleaming new boats crowded fish docks. When the Narragansett trawled over Georges Bank, it could haul in more than 100,000 pounds of fish, filling the hold to the brim with prime cod, haddock or flounder. But this evening it was the only boat to bring a catch to New Bedford. The workers took off 19,958 pounds of fish to be auctioned off the next morning: small amounts of cod and haddock, but also pollock, ocean catfish, cusk, hake, sea dabs, sole, skatewings, monkfish and a few halibut, with several hundred pounds of lobster thrown in for good measure.

Once the nation's richest fishing grounds, Georges Bank has been picked clean of the fish that bring top dollar. ''I've been unloading boats for years and it's the worst I've seen. It's terrible, terrible,'' said Glen Nunes, one of three fish lumpers tossing the catch into buckets down in the icy hold. Who's responsible for the overfishing that wrecked New England's key fish populations, throwing tens of thousands of people out of work? New Englanders have no one to blame but themselves. Armed with the latest science, public agencies made bad decisions repeatedly, declining to curb fishing until it was too late. It's the worst such disaster in the United States, but just one of many around the world — a growing list that has sparked a fierce debate about the way humans manage fish and other natural resources.

Scientists and fishers have attacked the principles that managers have used for the past century, saying they are relics rendered irrelevant by a quickly changing world. ''The system is based on a pipe dream. It's seductive but it isn't real,'' said Sylvia Earle, a former chief scientist at the National Oceanographic and Atmospheric Administration and author of the book ''Sea Change,'' which urges policy makers to take a more holistic view of ocean resources. ''The way we manage is not the way nature works,'' Earle said. ''Nature is not a test tube, but we're treating it like one, and the experiment is failing.''

The optimum yield -- Fishery managers attempt to control the amount of fishing with a two-part goal: maximizing the catch of fleets while maintaining a large enough population of fish to support fishing efforts year after year. In resource jargon, that level is called ''maximum sustainable yield.'' Variations of maximum sustainable yield have guided managers for decades. Current federal law makes the goal ''optimum yield,'' and requires managers to consider social impacts, such as the effects of overfishing or quota restrictions on fishers and their families.

The world is considerably more complicated than the parameters these neat, well-defined puzzles would indicate. As scientists run their computer models, unpredictable and often uncontrollable forces such as weather, politics and global capitalism conspire to thwart their best-laid plans. The traditional approach is ''based upon the false assumption that science is capable of furnishing

information reliable enough to allow a command-and-control approach to ecosystems,'' said Chris Finlayson, a fishery social scientist who did a study of Canadian mismanagement.

An influential article published in the journal Science in 1993 argued that the uncertainty in fisheries science, combined with widespread political and economic pressure to exploit the resource, has too often made long-term management impossible. ''In such circumstances, assigning causes to past events is problematical, future events cannot be predicted, and even well-meaning attempts to exploit responsibly may lead to disastrous consequences,'' wrote the authors, three fishery scientists. One basic problem, they said, is that scientists and managers are too ambitious: Their credibility is based on their ability to measure changes in fish populations. Often, they cannot.

''If you want to find what the truth is, you hold a series of experiments,'' said Donald Ludwig of the University of British Columbia, one of the authors. ''But you can't do that with fisheries. Too many interests are involved. There are constraints on getting data. It's very difficult to get any kind of sensible scientific experiment going.''

Scientists in labs experiment using trial and error. But fishery scientists are, in effect, running a big experiment with fish populations and fishers' lives. Trial and error, in this case, usually involve waiting to see exactly how much fishing causes a population to fall, then putting the brakes on until it comes back to the right level. The social costs of miscalculations are enormous. Fishery scientists and managers operate on a razor's edge. They must allow as much fishing as possible without allowing the fish population to collapse. And they are usually under pressure to move in the more dangerous direction, to keep fishers working and allow fishing to continue. When too much confidence is placed in their work, the results can be disastrous, as they were in Canada's Atlantic provinces. In Canada, fishing is a vastly more important industry than it is in the United States, and Canada's fishery management system is strong and centrally controlled by the Department of Fisheries and Oceans.

Some of the agency's surveys were finding fewer cod than commercial catch figures indicated. But scientists erred on the side of the fishing industry, giving more weight to the commercial figures because they offered a more upbeat picture. They ignored skepticism from some local fishing groups concerned that they were seeing fewer fish. They later found a reason for the discrepancy: Instead of being spread out uniformly, the fish populations were abundant only in some areas — and that was where the boats were. Overall, the population was much lower than expected. But even then, managers were caught between pressure to keep the catch as high as possible and their own conflicting data. They compromised. As a result, managers allowed too much fishing and the population collapsed almost entirely. It will take decades to come back, and it will never support the level of fishing it once did.

In New England, an equally destructive dynamic developed. National Marine Fisheries Service scientists had been reporting falling populations since the early 1980s. But the Fishery Management Council, bowing to pressure from boat owners, other industry interests and local congressmen, did little.

''Scientists have been screaming in the wind for the better part of a decade and were pretty much ignored,'' said Steven Murawski, a scientist in the Fisheries Service's Northeast Regional Laboratory in Woods Hole, Mass. ''It was just too late to pull these stocks out of the fire by the time there was general recognition of the seriousness of the problem.'' It ultimately took a lawsuit to get action. In 1991, the Conservation Law Foundation in Boston filed a lawsuit against

the U.S. secretary of Commerce, who oversees the Fisheries Service, claiming that the most recent management plan was illegal because it would not control overfishing. 'The lawsuit was settled in one face-to-face discussion about four hours long,'' said foundation attorney Peter Shelley. ''It was clear to us that they wanted to lose that case as quickly as possible.'' When government agencies resort to being sued to get things done, there is clearly something wrong.

The underlying ideas behind modern fisheries management date to the 18th century Enlightenment, a time when scientists and philosophers viewed the universe as a kind of giant, whirring timepiece. To understand it, all they had to do was divide it into its constituent parts and study how they fit together, said fishery social scientist Finlayson. Modern descendants of these ideas live on in government agencies, which have refined their good points, but also perpetuated their flaws. The Fisheries Service, for example, is overwhelmingly dominated by biologists who track population changes in single species of fish.

The agency gives much shorter shrift to fleet economics, fishing communities, fish habitat, or interactions with other species — things that are arguably just as important, if not more so.

On top of that, nature often behaves in unpredictable ways that can sandbag scientists and managers, even when they're doing what they do best — looking at the landings of a single species. Take the case of the gag grouper, a fish caught off the Florida coast in the Gulf of Mexico. For years, assessments showed the stock to be healthy. But biologists studying its behavior recently found it is transsexual; all gag groupers start out as females, then some change sex as they reach spawning age. Because the males are more aggressive and tend to swim higher in the water, they are fished out sooner. Complicating the phenomenon, females on the cusp of changing sex often start behaving like males, so they're fished out sooner too. While the gag grouper's total population was generally maintained at fishable levels during most of the past 20 years — meaning there was little rationale to protect it — the percentage of males in the population has dropped from 20 percent to 1 percent, a study showed. There's plenty of fish. It's just that they're almost all females, meaning soon there may not be enough males to sustain the population. ''If you continue to fish like this, there is not going to be a fishery in two or three years,'' said Florida State University biologist Felicia Coleman. The National Marine Fisheries Service and the Gulf of Mexico Fishery Management Council missed the boat on the gag grouper and several species that behave similarly, Coleman says. In some areas, those fish have already disappeared.

Changes in the U.S. fisheries law, the Magnuson Act, now up for renewal in Congress, will address some of these weaknesses. One reform would better define overfishing and give the Fisheries Service the power to stop it. The core of the problem, say fishers, scientists and managers, is not scientific but political.

In many places, there's no consensus either to abide by scientific surveys or, more generally, to conserve fish populations over the long run. Ideally, reformers argue, the size of fishing fleets ought to be limited and fishing should be restrained at a level safely below that razor's edge where surprises from nature or politics can cause disaster.

''What if you were in the dark, on a mountain road, with precipices and cliffs you could fall over without warning?'' said fishery scientist Ludwig. ''You'd be cautious.''

Quotas might save both fish and fishers

By JOHN McQUAID, *Staff writer*

OCEAN CITY, Md.

For years, surf clam fisherman Mike Garvilla was forced to shuffle paperwork under a bewildering array of regulations designed to protect the species from overfishing. Government agents told him which days and which hours he could fish, often regardless of the weather. Competition forced him to range far up the coast for days at a time. But six years ago, Garvilla, 36, became a rare phenomenon in these days of vanishing fish and eroding fishing jobs: a happy fisherman. Now he fishes whenever and wherever he wants. He takes his boat, the Betty C. II, about 15 miles due east of Ocean City — an easy two-hour trip. He drops the stern-mounted, 22-foot dredge with a built-in hydraulic pump, blasts clams out of the sand and into the metal cage, then hauls them to the surface with electric winches. He's back by mid-afternoon. ''It's a completely different situation,'' he said. ''We have our freedom, and it feels good for a change.''

Garvilla is part of a management experiment that could revolutionize fishing around the world by establishing property rights for fishers over the animals they catch for the first time in history. The program, proposed for the Gulf of Mexico red snapper, is called an Individual Transferable Quota. It would assign each certified fisher a share of the year's preset total catch. He could fish any time he wanted to fill that quota, or sell or lease his share to someone else. The change would be this century's version of fencing the open range — a government-sanctioned takeover of an open resource — all in the name of saving it.

The theory is alluring: Giving fishers a direct financial stake in the resource would encourage conservation and end the mad rush to outfish rivals, a competition that has depleted many fish populations. But the reality would mean painful trade-offs. ''There is a tradition of wanting all fisheries to have open access. That's a cultural thing,'' said Carolyn Creed, a fishery anthropologist who co-authored a Rutgers University study of the several ITQ programs, including surf clams. ''But the history of open access is pretty grim. So we're forced into the hard choices.'' If they are widely implemented as some experts predict, ITQs would transform commercial fishing in the Gulf into something unrecognizable. Only certified ''professional'' fishers could work. The lucky ones, however, would probably be better off.

Creating property rights over fish would turn fishing into something closer to farming, with the crop effectively owned by the people who bring it in. ITQs are supposed to bring the free market to bear on fishing fleets, where normal market forces have been distorted by subsidies, overinvestment and the unconventional economics of a resource owned by no one. In some places, they have had positive results. New Zealand has ITQs for 32 species of fish, part of a coordinated fishery development and management program. Fishing employment and ownership of quota shares has risen in the past 10 years, cutting against the trend of economic collapse elsewhere in the world. ITQs address the problem of overbuilt fleets by strictly limiting who may fish — usually those with a documented history of catching the fish being regulated.

Managers assign a fraction of an annual quota to each fisher — or in some cases, each boat or fishing enterprise. The fisher must stop once the quota is reached. That eliminates the short seasons and derby fishing found in many fisheries, including the red snapper. Instead of seeing prices drop when everyone sells their catch at once during a derby, landings would be spread over time and the price would remain stable. Finally, the T in ITQ means they can be transferred,

creating a marketplace for the shares, a policy designed to consolidate them in the most economically efficient hands. Transferability would accelerate the slow shakeout of boats and employment occurring around the world, almost instantly creating winners and losers. And in many places, the losers would greatly outnumber the winners.

Revealing experiment -- The surf clam fishery was ideal for the ITQ experiment in ways many others are not. Boats sell only to a few companies that make processed fish products. The fleet size — about 135 boats — made it easier to arrive at a consensus among boat owners.

Still, its lessons are dramatic.

Before the ITQ system took effect, the fleet was in bad shape. ''Expenses had gone up, the fleet had become old, boats were unsafe, they'd lost people at sea. There was a knowledge that as things stood, many were going to go out of business. It just wasn't working,'' Creed said. With an overall catch capped to preserve the stock, boats could fish only once every two weeks, for six hours. In Garvilla's case, it was every other Tuesday, from 8 a.m. to 2 p.m. If the weather on the designated day was bad, fishers could make it up the next day. But if bad weather continued, they had to wait another two weeks. That, and other mishaps such as engine trouble, often left them losing money.

When the ITQ program started in 1990, after a period of meetings and consensus-building among the boat owners and managers of the Mid-Atlantic Fishery Management Council, most boat owners ended up with small quotas. ''I did not have enough allocation to make a living at it,'' said Joe Garvilla, Mike's father, who owns the Betty C. II along with his son. ''If the quota is divided up properly at first, everybody is going to be unhappy. So when you come up with an ITQ plan, you've either got to buy or sell.'' Over the next five years, the fleet size dropped by about 100 boats as their owners sold or leased their shares. Most of the boats ended up junked.

Many people lost their jobs when companies and individuals consolidated their shares, though the number of jobs was shrinking even before the program began. But ITQs also provide a means for struggling boat owners to get out, something not easily accomplished before. ''It allows them to leave the fishery with some resources,'' said Rutgers fishery anthropologist Bonnie McCay, who collaborated on the ITQ study with Creed. ''If you quit farming you can sell the farm and move to Florida. In fishing, that's not the case because your boat has depreciated.'' With the experimental system, fishers have their quotas to sell.

But ITQs have sparked bitter opposition. Opponents say transferability would allow large entities to come in and dominate small operators — in effect eliminating the freedom that defines fishing, turning fishers into little better than sharecroppers. Even before the ITQ process started, big companies combining all the elements of seafood production — fishing, processing and marketing — dominated the surf clam fishery. ITQs accelerated the process.

Without limits on shares, critics say, ITQs could allow companies to corner a market and set the price, leaving consumers at their mercy. Proponents say the rules can be written to prevent concentrating too many shares in too few hands. Managers like the quota system because it's simpler than the current snarl of regulations. But whether it promotes conservation is unclear. McCay and Creed's study, for example, showed that in one Canadian fleet, it tended to increase the capture of bigger fish to ensure the largest profit margin — a practice that removes the best breeders from a stock. And under the U.S. system, the overall quotas would still be set by the

regional Fishery Management Councils, which have often caved in to industry pressure to relax or delay conservation measures.

Meanwhile, Congress has gotten jittery on the issue. It appears poised to put off new ITQ programs for five years so they can be studied further, which may increase pressure on fish stocks. ‘‘There will be a mad rush by assorted fishing interests to acquire catch histories during the period of the moratorium so that they will be in a position to claim shares when it ends,’’ said international fishery consultant Francis Christy, who is credited with introducing ITQs. ‘‘It will be the trumpet call for the start of a massive derby.’’

ITQ proponents say it’s transferability that makes the system work. Without it, they say, there is no way to consolidate shares, but also no incentive — and perhaps no way — for small operators to make their enterprises more profitable or even to get out of the business. ‘‘Without transferability, this is a crock,’’ said Louisiana red snapper fisher Ron Anderson, who supports the ITQ snapper program, which was set to start this year but is now in political limbo.

Bold new ‘chaos theory’ says fishery experts way off track

By JOHN McQUAID, *Staff writer*

For most of this century, the custodians of our fisheries have taken a single-minded approach: Study one fish and control the fleet that catches it. This idea is almost an article of faith among managers and biologists who dominate the field. Dozens of government agencies are devoted to it, hundreds of university programs initiate marine biologists into its mysteries, and it is propagated in the attitudes handed down from one generation of scientists to the next.

So what happens when it doesn’t work?

Collapsing fish stocks and a rash of mysterious occurrences such as the oxygen-depleted ‘‘dead zone’’ in the Gulf of Mexico have called into question the basic principles used to manage resources since the early 1900s, which say the best way to manage fisheries is to count the fish and control fishing accordingly.

Fish vs. ecosystem -- Instead of looking at how individual parts of an ecosystem operate in isolation, new disciplines look at the behavior of entire systems. The emerging fields — chaos and complexity theory and ecological science — could ultimately supplant traditional methods. They look for ways to explain what traditional scientists consider unexplainable — wild fluctuations in fish populations, for example, that often confound fishery managers and paralyze management.

Traditional science operates on the assumption that natural systems like fish populations exist in balance. But in reality they are in constant flux — spiking up and down, with many overlapping cycles — and can be upset by even tiny changes. That’s where the new approaches come in. Chaos scientists, for example, try to find order in what looks like chaos. They have found complex equations, called nonlinear in mathematics jargon, that describe many common, previously inexplicable behaviors.

An example of chaos science at work involves the relationship between the population of fish spawning and their offspring. Most fish release millions of eggs, a fraction of which survive and grow into baby fish. The numbers of baby fish left alive for fishers to catch vary wildly year to year, seemingly independent of the numbers of parents. That makes measuring the total population problematic.

Most fishery scientists treat the internal dynamics of spawning, affected by thousands of factors such as ocean currents, predators and temperature changes, as random and unknowable. ‘‘Someone with a standard view would say that all the stuff that I can’t explain is noise. The nonlinear view is, maybe I can get something out of that,’’ said George Sugihara, a biophysicist at the Scripps Institution of Oceanography at the University of California at San Diego. ‘‘Noise is not an objective thing. It’s a statement of our own ignorance.’’

Take the case of the damselfish, a common aquarium fish that spawns off Australia’s Great Barrier Reef. In a recent study that Sugihara supervised, scientists focused on what happens when fish spawn at their nests, which are clustered on the sea floor, defended by male fish. When the larvae emerged, the scientists measured wind speed and direction, phases of the moon and

other factors, then 30 days later observed what happened with the population's size, repeating the experiment many times.

They were able to show that the successive shifts in the population of new fish were caused in part by a single environmental factor: wind speed. Their equation showed that wind speed accounted for 64 percent of the fluctuations. The statistical analysis used in most fish stock assessments was able to account for only 5 percent.

If scientists could routinely isolate the environmental factors that influence the size of each year's crop of fish, they would have a powerful tool to manage fishing.

Variables infinite -- Some practitioners of chaos theory go the opposite route, seeking to describe not the interactions of just one or two things, but billions. Sometimes, patterns of order emerge even at the global level. They can be described, even predicted, with the right equation. Chaos scientist Stephen Guastello of Marquette University in Milwaukee applied predator-prey dynamics to the world fish catch. Predators, in this case, are fishing boats, and prey are fish. The relationship between populations of predators and prey can display chaotic cycles in which one rises, then the other falls. No two cycles are alike.

By tracking catches in 16 regions monitored by the United Nations — most of which have been falling since the late 1980s — he derived a nonlinear equation that showed several possible trends for the future catch. Nonlinear equations can have multiple solutions. One showed a decline bottoming out last year, then wobbling at weak levels — not making a recovery for 36 years. Another possible trend showed the catch falling indefinitely.

Scientists are using other approaches to study dynamic change. Ecologists study ecosystems — marshes, oceans, deserts — where many populations interact with each other and the environment. Sometimes they treat the economy as a part of the ecosystem. The ecosystem approach is especially useful for the Gulf of Mexico, where almost all commercially important fish species depend on marsh habitats in constant flux.

''The standard models don't really address the issue of habitat at all — just fish population,'' said Robert Costanza, director of the University of Maryland's Institute for Ecological Economics. ''Particularly in places like Louisiana with a lot of interactions with coastal wetlands, addressing habitats is what you need to do.'' Costanza was the principal designer of a computer model that projected long-term changes in a section of the Atchafalaya marsh. The model divided the area into a checkerboard of 2,479 squares, each a square kilometer.

The scientists took data from detailed maps compiled by the U.S. Fish and Wildlife Service on three occasions over 27 years to map the actual changes in the marsh. They used a weekly record of climate conditions in the area during the same period — rainfall, temperature, wind, river flow, and sediment and nutrient concentrations. Plugging all this into the model, they were able to chart a continuous change in each square over decades, and get a picture of how the marsh was evolving.

To see what the marsh might look like in the future, the scientists plugged in different scenarios for climate, sea level, man-made structures and other factors. One result: The model showed that random, catastrophic events such as hurricanes and floods have a greater cumulative effect on marsh erosion than daily tidal flows and the annual flood cycle.

Tradition dies hard -- Ecosystem scientists argue for a shift away from just managing fishing toward a more comprehensive approach taking into account habitat, current flow and interactions with other species. But the new approaches face many obstacles. Scientists violently disagree, for example, on the role of chaotic changes in fish populations. Many fishery scientists say any chaotic changes will almost always be impossible to separate from other factors that aren't chaotic. And while agencies such as the National Marine Fisheries Service employ new techniques as they can, they must function in an era when government is shrinking — not expanding its mandates across entire ecosystems.

''One reason fish management spends a lot of effort on controlling fishing is that's what the law allows fish managers to control. That has the most immediate impact, and that's what the public is most concerned about,'' said Bradford Brown, director of the Southeast Regional Science Center of the Fisheries Service, who is also an expert on ecosystem modeling. But the biggest problem is history. Institutions are set up and budgets are determined the way they are because agencies have been doing it that way for decades, not because their approaches are the best. ''The people who are the principal proponents of current theory are government scientists who have a large vested interest in it,'' said James Wilson, a fishery economist at the University of Maine and a proponent of alternative management approaches.

''From my perspective, there's a problem in that the government has had a monopoly on the science in this area.''
